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# **Plans for Validation of Version 5 AIRS Products**

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## The Aqua Project Validation Status

- *Stage 1:* Validation Product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods and ground-truth/field program effort.
- *Stage 2:* Validation Product accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.
- *Stage 3:* Validation Product accuracy has been assessed, and the uncertainties in the product well-established via independent measurements made in a systematic and statistically robust way that represents global conditions.



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# Aqua Project AIRS Validation Status

AIRS Product	Uncertainty Estimate (Version 5)	Val Status (Version 5)	Source
<b>Radiances</b>			
AIRS IR Radiance	<0.2%	Stage 3	Project
AIRS VIS/NIR Radiance	15-20%	Stage 1	Project
AMSU Radiance	1-3 K	Stage 3	Project
HSB Radiance	1-3 K	Stage 3	Project
<b>Core Products</b>			
Cloud Cleared IR Radiance	1.0 K	Stage 2	Project
Sea Surface Temperature	1.0 K	Stage 2	Project
Land Surface Temperature	2-3 K	Stage 1	Project
Temperature Profile	1 K / km	Stage 2	Project
Water Vapor Profile	15% / 2km	Stage 2	Project
Total Precipitable Water	5%	Stage 2	Project
Fractional Cloud Cover	20%	Stage 2	Project
Cloud Top Height	1 km	Stage 2	Project
Cloud Top Temperature	2.0 K	Stage 2	Project
<b>Necessary Products*</b>			
Total Ozone Column	5%	Stage 2	Project
Ozone Profile	20%	Stage 2	Project
IR Dust**	0.5 K	Stage 1	Project
<b>Research Products</b>			
Carbon Monoxide	15%	Stage 2	NOAA/UMBC
Methane	2%	Stage 1	NOAA
Carbon Dioxide**	1-2 ppm	Stage 1	NASA/NOAA
OLR	5 W/m <sup>2</sup>	Stage 1	GSFC
HNO <sub>3</sub> **	0.2 DU	Stage 1	NOAA/UMBC
Sulfur Dioxide**	1 DU	Stage 1	NOAA/UMBC

\*Necessary Products are required to retrieve accurate temperature profiles (1K/km) in all conditions

\*\*Product not yet available in AIRS Level 2 Files. Products will be available in Version 6



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## What the NASA Aqua Senior Review says:

**“Current data products are in various stages of validation, but the AIRS products, being new and complex in nature, are lagging behind the development and dissemination of other Aqua measurements. The AIRS core data products ought to be brought to maturity prior to the end of the Prime mission in September 2008.” (page 5)**



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# Our Validation Schedule as of September 2003

## AIRS PRODUCT VALIDATION TIMELINE

Product	Version	3.0	4.0	5.0	6.0	7.0	8.0
	Activation Date	Aug 03	Sept 04	Jun 05	Mar 06	Dec 06	Sept 07
Level 1B Radiances	AIRS Radiance	Prov	Val2	Val4	Val5		
	VIS/NIR Radiance	Prov	Val2	Val4	Val5		
	AMSU Radiance	Beta	Prov	Val2	Val4	Val5	
	HSB Radiance	Beta	Prov	Val2	Val4	Val5	
Level 2 Standard Product	Cloud-Clear IR Radiance	Beta	Val2	Val3	Val4	Val5	
	Surface Temperature	Beta	Val2	Val3	Val4	Val5	
	Temperature Profile	Prov	Val2	Val3	Val4	Val5	
	Humidity Products	Beta	Val1	Val2	Val3	Val4	Val5
	Cloud Cover Products	N/A	Beta	Val1	Val2	Val2	Val3

**Beta** = Not suitable for scientific investigations. Consult with AIRS Project on regional status.

**Prov** = Provisionally validated. Useable for scientific investigations with caution. Validated for nonpolar night ocean only

**Val1** = non-polar day/night ocean

**Val2** = Val1 + non-polar night land

**Val3** = Val2 + nonpolar day land

**Val4** = Val3 + polar night

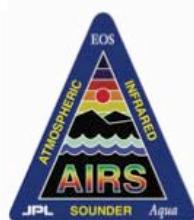
**Val5** = Val4 + polar day. Only Val5 data are useable for truly global scientific investigations.



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# We're putting together a V5 Val Plan

## The AIRS Team Science Data Validation Plan *for Version 5 Data Release*



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AIRS Team Leader

Edited by:  
E. Fetzer

Contributions by:

E. Olsen, T. Pagano, ...

Version 1.0

October 3, 2007  
JPL D-XXXXX



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## Some topics for V5 analyses using validation data (with candidates)

**More topics are welcome; volunteers are needed:**

- Land T and q in the boundary layer using dedicated sondes (Tobin, Hearty).
- Polar water vapor and temperature (Tobin, Walden, Ye, Gettelman).
- Sampling biases (Fishbein, Fetzer, Divakarla, Tobin).
- Ozone (Divakarla, Pan, Irion).
- Other minor gases (McMillan, Irion).
- CloudSat comparisons (Kahn).
- Land surface temperature (Knuteson).



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## Some Topics for science analyses using validation data (continued)

- Surface exchange processes (Santanello & many others).
- Error estimates, averaging kernels, vertical resolution (Susskind, Irion).
- Profiles over stratocumulus (Teixeira, Fetzer)
- Upper trop humidity with dedicated (Aura) sondes (?)
- Assess L3 against ECMWF (Granger)
- Minor gas comparisons with other A-Train sources (McMillan, Irion)
- Tropopause structure (Tian, Fetzer).



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## The V5 Validation Plan

- Much of the work is motivate by the Aqua Senior Review.
- We need validation papers, especially for difficult products and conditions.
- Primarily science driven
  - *What do we need to know to answer the “twenty questions”?*
  - *How do we improve the science analyses presented earlier?*
- Comments are welcome.



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# The V5 Validation Report

- ***Core Products must be completed by September 2008 (see Senior Review comments).***
  - ***We need contributions!***
- **This V5 Val Report be a very short document summarizing published results, as in:**

Fetzer, E. J. (2006), Preface to special section: Validation of Atmospheric Infrared Sounder Observations, *J. Geophys. Res.*, 111, D09S01, doi:10.1029/2005JD007020.



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## *Generally:* We are data rich, analysis poor

### We have:

- Five years of AIRS observations.
- Correlative data sources
  - *ECMWF and NCEP reanalyses.*
  - *Thousands of operational and dedicated sondes*
    - Europeans, ARM, field campaigns including Aura validation.
  - *Aircraft and field campaigns for several minor gases.*
  - *Similar observations from the A-Train*
    - H<sub>2</sub>O, O<sub>3</sub>, CH<sub>4</sub> and CO from TES and MLS.
    - Cloud properties from CloudSat, MODIS, MLS and AMSR.



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## Two Quotes

**“There are some obvious redundancies between the new AIRS products and MOPITT (CO) and TES (CO, O<sub>3</sub>) with no clear plan for producing either a single combined product or at least two, rationalized, non-conflicting data products. While the AIRS measurements have different vertical averaging kernels, there is so much overlap that inconsistencies will become apparent once these products are used by the community.”**

-- *Aqua Senior Review (p. 13)*

**“To bridge the gap between what the data-collection community provides and what the modeling community needs, the task of *data integration* is absolutely essential. Unfortunately, it is always in danger of being ignored. Data integration consists of bringing together data from disparate instruments, and combining these data into a coherent physical description of what was observed, in a form suitable for use in the evaluation of the relevant models.”**

-- *The 2nd GEWEX Cloud System Study Science and Implementation Plan, 2000.*



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# AIRS Data Integration is Already Underway

- **Several ROSES proposals will use multi-instrument observations**
- **See also:**

Fetzer, E. J., B. Lambigtsen, A. Eldering, H. H. Aumann, and M. T. Chahine (2006), Biases in total precipitable water vapor climatologies from Atmospheric Infrared Sounder and Advanced Microwave Scanning Radiometer, *J. Geophys. Res.*, 111, D09S16, doi:10.1029/2005JD006598.

Kahn, B. H., A. Eldering, A. J. Braverman, E. J. Fetzer, J. H. Jiang, E. Fishbein and D. L. Wu, 2007: Towards the characterization of upper tropospheric clouds using AIRS and MLS observations, *J. Geophys. Res.*, 112, D05202, doi:10.1029/2006JD007336.

Kahn, B. H., E. Fishbein, S. L. Nasiri, A. Eldering, E. J. Fetzer, M. J. Garay and S.-Y. Lee, 2007a: The radiative consistency of AIRS and MODIS cloud retrievals, *J. Geophys. Res.*, 112, D09201, doi:10.1029/2006JD007486.



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# Finally...

- All ideas and plans are welcome.
- Every contribution is valuable!



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# Thanks to all the authors of validation papers (and apologies to those I've missed...)

- Aumann, H.H., S. Broberg, D. Elliot, S. Gaiser, D. Gregorich (2006), Three years of Atmospheric Infrared Sounder radiometric calibration validation using sea surface temperatures, *J. Geophys. Res.*, 111, D16S90, doi:10.1029/2005JD006822.
- Bian, J., A. Gettelman, H. Chen, and L. L. Pan (2007), Validation of satellite ozone profile retrievals using Beijing ozonesonde data, *J. Geophys. Res.*, 112, D06305, doi:10.1029/2006JD007502.
- Cho, C., and D. H. Staelin (2006), Cloud clearing of Atmospheric Infrared Sounder hyperspectral infrared radiances using stochastic methods, *J. Geophys. Res.*, 111, doi:10.1029/2005JD006013.
- Divakarla, M., C. Barnet, M. D. Goldberg, L. McMillin, E. S. Maddy, W. W. Wolf, L. Zhou, and X. Liu (2006), Validation of Atmospheric Infrared Sounder temperature and water vapor retrievals with matched radiosonde measurements and forecasts, *J. Geophys. Res.*, 111, doi:10.1029/2005JD006116.
- Fetzer, E. J. (2006), Preface to special section: Validation of Atmospheric Infrared Sounder Observations, *J. Geophys. Res.*, 111, D09S01, doi:10.1029/2005JD007020.
- Fetzer, E. J., B. Lambrightsen, A. Eldering, H. H. Aumann, and M. T. Chahine (2006), Biases in total precipitable water vapor climatologies from Atmospheric Infrared Sounder and Advanced Microwave Scanning Radiometer, *J. Geophys. Res.*, 111, D09S16, doi:10.1029/2005JD006598.
- Froidevaux, L., N. J. Livesey, W. G. Read, Y. B. Jiang, C. Jimenez, M. J. Filippiak, M. Schwartz, M. L. Santee, H. Pumphrey, J. H. Jiang, G. L. Manney, B. J. Drouin, J. W. Waters, E. J. Fetzer, P. F. Bernath, C. D. Boone, K. A. Walker, K. W. Jucks, G. C. Toon, J. J. Margitan, C. R. Webster, L. E. Christensen and J. W. Elkins (2006), Early validation analyses of the atmospheric profiles from EOS MLS on the Aura satellite, Accepted to *IEEE Trans. Geosci. and Remote Sensing*.
- Gettelman, A., E. M. Weinstock, E. J. Fetzer, F. W. Irion, A. Eldering, E. C. Richard, K. H. Rosenlof, T. L. Thompson, J. V. Pittman, C. R. Webster and R. L. Herman, 2004: Validation of Aqua satellite data in the upper troposphere and lower stratosphere with in-situ aircraft instruments. *Geophys. Res. Lett.*, vol. 31, L22107, doi:10.1029/2004GL020730.



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## Thanks to all the authors of validation papers (continued)

- Gettelman, A., V. P. Walden, L. M. Miloshevich, W. L. Roth, and B. Halter (2006), Relative humidity over Antarctica from radiosondes, satellites, and a general circulation model, *J. Geophys. Res.*, 111, D09S13, doi:10.1029/2005JD006636.
- Hagan, D. E., C. R. Webster, C. B. Farmer, R. D. May, R. L. Herman, E. M. Weinstock, L. E. Christensen, L. R. Lait and P. A. Newman (2004), Validating AIRS upper atmosphere water vapor retrievals using aircraft and balloon in situ measurements, *Geophys. Res. Lett.*, 31, L21103, doi:10.1029/2004GL020302.
- Kahn, B. H., A. Elderling, A. J. Braverman, E. J. Fetzer, J. H. Jiang, E. Fishbein and D. L. Wu, 2007: Towards the characterization of upper tropospheric clouds using AIRS and MLS observations, *J. Geophys. Res.*, 112, D05202, doi:10.1029/2006JD007336.
- Kahn, B. H., E. Fishbein, S. L. Nasiri, A. Elderling, E. J. Fetzer, M. J. Garay and S.-Y. Lee, 2007a: The radiative consistency of AIRS and MODIS cloud retrievals, *J. Geophys. Res.*, 112, D09201, doi:10.1029/2006JD007486.
- McMillan, W. W., C. Barnet, L. Strow, M. T. Chahine, M. L. McCourt, J. X. Warner, P. C. Novelli, S. Korontzi, E. S. Maddy and S. Datta (2005), Daily global maps of carbon monoxide from NASA's Atmospheric Infrared Sounder, *Geophys. Res. Lett.*, 32, L11801, doi:10.1029/2004GL021821.
- Miloshevich, L. M., H. Voemel, D. Whiteman, B. Lesht, F. J. Schmidlin, and F. Russo (2006), Absolute accuracy of water vapor measurements from six operational radiosonde types launched during AWEX-G and implications for AIRS validation, *J. Geophys. Res.*, 111, doi:10.1029/2005JD006083.
- Nalli, Nicholas R., et al. (2006), Ship-based measurements for infrared sensor validation during Aerosol and Ocean Science Expedition 2004, *J. Geophys. Res.*, 111, doi:10.1029/2005JD006385.
- Rama Varma Raja, M. K., S. I. Gutman, J. G. Yoe, L. M. McMillin, and J. Zhao, (2007), The validation of AIR retrievals of integrated precipitable water vapour using measurements from a network of ground based gps receivers over the contiguous united states, *J. Atmos. Oceanic. Tech.*, 2007, accepted.
- Rosenkranz, P. W. (2006), Cloud liquid-water profile retrieval algorithm and validation, *J. Geophys. Res.*, 111, D09S08, doi:10.1029/2005JD005832.
- Rosenkranz, P. W., and C. D. Barnet (2006), Microwave radiative transfer model validation, *J. Geophys. Res.*, 111, D09S07, doi:10.1029/2005JD006008.



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## Thanks to all the authors of validation papers (continued)

- Strow, L. L., S. E. Hannon, S. De-Souza Machado, H. E. Motteler, and D. C. Tobin (2006), Validation of the Atmospheric Infrared Sounder radiative transfer algorithm, *J. Geophys. Res.*, 111, D09S06, doi:10.1029/2005JD006146.
- Susskind, J., C. Barnet, J. Blaisdell, L. Iredell, F. Keita, L. Kouvaris, G. Molnar, and M. Chahine (2006), Accuracy of geophysical parameters derived from Atmospheric Infrared Sounder/Advanced Microwave Sounding Unit as a function of fractional cloud cover, *J. Geophys. Res.*, 111, D09S17, doi:10.1029/2005JD006272.
- Tobin, D.C., H. E. Revercomb, R. O. Knuteson, B. Lesht, L. L. Strömgren, S. E. Hannon, W. F. Feltz, L. Moy, E. J. Fetzer, and T. Cress (2006), Atmospheric Radiation Measurement site atmospheric state best estimates for Atmospheric Infrared Sounder temperature and water vapor retrieval validation, *J. Geophys. Res.*, 111, D09S14, doi:10.1029/2005JD006103.
- Tobin, D.C., et al. (2006), Radiometric and spectral validation of Atmospheric Infrared Sounder observations with the aircraft-based Scanning High-Resolution Interferometer Sounder, *J. Geophys. Res.*, 111, D09S02, doi:10.1029/2005JD006094.
- Tobin, D.C., H. E. Revercomb, C. C. Moeller, and T. Pagano (2006), Use of Atmospheric Infrared Sounder high-spectral resolution spectra to assess the calibration of Moderate resolution Imaging Spectroradiometer on EOS Aqua, *J. Geophys. Res.*, 111, D09S05, doi:10.1029/2005JD006095.
- Walden, V., W. Roth, R. S. Stone, and B. Halter (2006), Radiometric validation of the Atmospheric Infrared Sounder (AIRS) over the Antarctic Plateau, *J. Geophys. Res.*, 111, D09S03, doi:10.1029/2005JD006357.
- Whiteman, D., et al. (2006), Analysis of Raman lidar and radiosonde measurements from the AWEX-G field campaign and its relation to Aqua validation, *J. Geophys. Res.*, 111, D09S09, doi:10.1029/2005JD006429.
- Ye, H., E. J. Fetzer, D. H. Bromwich, E. F. Fishbein, E. T. Olsen, S. Granger, S.-Y. Lee, L. Chen and Bjorn H. Lambrigtsen (2007), Atmospheric total precipitable water from AIRS and ECMWF during Antarctic summer, *Geophys. Res. Lett.*, 34, L19701, doi:10.1029/2006GL028547.